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Important chemical and physical traits and variation in these traits in 'tombul' hazelnut cultivar at different elevations

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RESUMEN

Importantes rasgos químicos y físicos y variación en estos rasgos en plantaciones de avellana 'Tombul' en diferentes elevaciones.

Este estudio ha sido realizado en la avellana 'Tombul' que crece en cuatro elevaciones (0-50 m, 100-150 m, 200-250 m y 300-350 m) en la provincia de Persembe (Ordu/ Norte de Turquía) en los años 1999 y 2000. Dieciséis rasgos (contenido en aceite, proteína y ceniza como características químicas; peso, tamaño y grosor de cáscara, peso, tamaño y porcentaje del grano, cavidad interna, granos arrugados y granos buenos como características físicas; pH, materia orgánica, fósforo y potasio en el suelo) han sido examinados en cada elevación. Las correlaciones entre características importantes del suelo, de la cáscara y del grano fueron examinadas. Las correlaciones fueron significativas positivamente entre tamaño de la cáscara-aceite, y aceite-proteína; negativamente entre proteína-tamaño grano, y proteína-grano arrugado; negativamente entre materia orgánica-grosor de cáscara, y materia orgánica-grano bueno; negativamente entre pH-grosor de cáscara, y pH-grano bueno; positivamente ente grano bueno-grosor de cáscara; negativamente entre grano arrugado-peso del grano, y grano arrugado-porcentaje del grano; positivamente entre cavidad interna-peso de cáscara y negativamente entre cavidad interna-tamaño de cáscara; positivamente ente porcentaje del grano- peso del grano, y porcentaje del grano-tamaño del grano; positivamente entre tamaño del grano-peso del grano, y peso de cáscara-peso del grano. Diferencias significativas entre elevaciones han sido observadas para el grosor de cáscara, el contenido de ceniza en el grano, y pH en el suelo. Los coeficientes de variación más altos han sido observados para el fósforo, granos arrugados, potasio, cavidad interna y materia orgánica, respectivamente.

PALABRAS-CLAVE: Corylus avellana L - Grano - Química - Física -- Cáscara - Suelo.

SUMMARY

Important chemical and physical traits and variation in these traits in 'Tombul' hazelnut cultivar at different elevations.

This study was conducted on 'Tombul' hazelnut growing at four elevations (0-50 m, 100-150 m, 200-250 m and 300-350 m) in Persembe (Ordu/ Northern Turkey) province in 1999 and 2000 years. Sixteen traits (oil, protein and ash contents as chemical; nut weight, nut size, shell thickness, kernel weight, kernel size, percent kernel, internal cavity, shriveled kernels, good kernels as physical; pH, organic matter, phosphorus and potassium in soil) were examined at each elevation. Interrelationships among important soil, nut and kernel characteristics were examined. There were significant correlation and interrelationships among the traits. The correlation between oil-nut size, oil- protein positively; protein-kernel size, protein- shriveled kernel negatively; organic matter- shell thickness, organic matter-good kernel negatively; pH- shell thickness, pH-good kernel negatively; good kernel-shell thickness positively; shriveled kernel-kernel weight, shriveled kernel-percent kernel negatively; internal cavity-nut weight positively and internal cavity-nut size negatively; percent kernel-kernel weight, percent kernel-kernel size positively; kernel size-kernel weight positively, and kernel weight-nut weight positively were significant. Significant differences among elevations were observed for shell thickness, ash content in kernel, and pH value in soil. The highest coefficients of variation were observed for phosphorus, shriveled kernels, potassium, internal cavity and organic matter, respectively.

KEY-WORDS: Corylus avellana L - Kernel -- Chemical -- Physical -- Nut - Soil.

1. INTRODUCTION

The world's major hazelnut production areas are all located near large bodies of water and are characterized by mild, humid winters and cool summers, although the geographical range of the European hazelnut includes a wide range of climates, from subtropical along the Mediterranean to very cold in Scandinavia and Russia (Mehlenbacher, 1994). There are great genetic variability in *Corylus avellana* L., and most cultivars existing today are the result of natural selection and selection by man (Lagerstedt, 1975; Mehlenbacher, 1991).

Clonal variability in old fruit and nut cultivars is a widely recognized phenomenon and hazelnuts are no exception. Breeding goals regarding tree growth habit and adaptation to environmental factors vary in different regions, depending on local cultural practices and differing adaphic, climatic, pest, and disease problems. Traits such as adaptation to higher soil pH, greater cold hardiness, etc. are required for specific regions. All important world cultivars were selected at some unknown, distant time directly from the wide-ranging wild species, *Corylus avellana* L., in Europe and Turkey (Thompson et al., 1996).

In Turkey, conventional production practices arising from a variety of factors have long been used and adoption of improved production technologies is quite limited. In modern hazelnut production, development of high yielding cultivars with desired quality, suitable for processing and meeting the

needs of domestic and international markets is of considerable importance (Ayfer et al., 1986).

In hazelnut orchards involving a variety of cultivars and forms, the harvested crop is a heterogeneous mixture. In Turkey, hazelnuts are grown between 0 m and 750 m elevation. The zone between 0 m and 250 m, 250 m and 500 m and 500 m and 750 m are called coastal line, middle line and high line, respectively.

In the growing, 'ocak' (a traditional bush system) planting system have been used. In the ocak system, spacing between ocaks is 3-5 m, and stem number per ocak is 6-12 in practice.

The 'Tombul' hazelnut cultivar has a high protein (16.79-18.03 %) and oil (65.92-67.98 %) (Ayfer et al., 1986). In the province of Persembe (Ordu), 'Tombul' and 'Palaz' hazelnut cultivars are well adapted, and 'Tombul' is the main variety grown. 'Tombul' hazelnut orchards have a 65 % area among the hazelnut cultivars in Persembe. The fruit of this variety has a round shape.

There is a great potential for genetic improvement by means of selection in the region. The purpose of this study was to determine the interrelationships among soil, nut and kernel traits, and variation associated with elevation for the soil, nut and kernel characteristics in 'Tombul' hazelnut cultivar grown in Persembe (Ordu) province.

The use of path analysis provides a plausible explanation of observed correlation by modeling the cause-and effect relations between the variables. Thus, it is possible to analyze the correlation coefficient of variables in the form of variance and covariance using path analysis.

2. MATERIALS AND METHODS

This research was conducted on 'Tombul' hazelnut grown at orchards with 50 ages and four elevations (0-50 m, 100-150 m, 200-250 m and 300-350 m) in Persembe (Ordu/Northern Turkey) that its area is 224 km^2 province in 1999 and 2000 years.

Sixteen traits were observed: Oil (O, %), protein (PR, %), ash content (A, %) in kernel; nut weight (NW, g), nut size (NS, cm) ((nut width +nut length +nut thickness)/3), shell thickness (ST, mm), kernel weight (KW, g), kernel size (KS, cm) ((kernel width +kernel length +kernel thickness)/3), percent kernel, (RK, %), internal cavity (IC, mm), shriveled kernels (SK, %), good kernels (GK, %); pH, organic matter (OM, %), phosphorus (P, ppm), potassium (K, ppm) in soil.

Chemical analysis were determined as follows:

Ash content: 1 g sample was weighed in porcelain cups and was burned at $550 \pm 2\ ^{o}C$ until white color comes into existence. The results were given as percent (Anonymous, 1988).

Protein content: Protein content was determined according to kjheldahl method by utilizing total nitrogen amount (Kacar, 1984).

Oil content: This was determined as percent by soxhalet apparatus (warm extraction) using diethyl ether solvent (Kadaster, 1960).

pH : pH in 1:1 (w/v) soil water suspension by pH-meter (Jackson, 1962).

Organic matter: Soil organic matter content was measured by Walkley Black method (Jackson, 1962).

Potasssium (K): Soil available K content was determined using Flame Photometry (Rowell, 1994).

Phosphorus (P): Soil available P content was determined as Spectrophotometric according to Olsen (Rowell, 1994).

Three orchards were selected at each elevation. These orchards were similar with respect to technical and cultural practices, and slope. These orchards had been planted by materials that had been propagated by suckers. In the orchards, ocak number was changed between 50-60/1000 m^2. Nut samples were harvested 1 and 15 August, in 1999 and 2000 years, respectively, and dried under natural conditions. Soil samples were taken 15 days ago from harvest.

The experimental design was completely randomized design with three replicates. Three ocak (a traditional bush system) were used at each replicate. Interrelationships among the traits were determined by path analysis on computer program.

3. RESULTS AND DISCUSSION

Significant interrelationships among traits were determined (Table I). Total 17 significant correlations were determined for sixteen traits. Nut weight-kernel weight, nut weight-internal cavity, nut size-oil content, shell thickness-good kernels, kernel weight-kernel size, kernel weight-percent kernel, kernel size-percent kernel and oil content-protein content correlation as positively, and nut size-internal cavity, shell thickness-pH, shell thickness-organic matter, kernel weight-shriveled kernel, kernel size-protein content, percent kernel-shriveled kernel, shriveled kernel-protein content, good kernel-organic matter and good kernel-pH correlation as negatively were determined significantly.

In a study that was conducted on 'Tombul' hazelnut negative correlation between nut weight and percent kernel, shell thickness and percent kernel; positive correlation between nut weight and kernel weight, nut thickness and shell thickness, shell thickness and kernel weight were observed significantly (Bostan, 1995). Our result for the nut weight and kernel weight correlation was similar to literature. But, the other correlations were not significant in this study.

Table I
Correlation coefficients between traits in 'Tombul'

NW	NS	ST	KW	KS	PK	IC	SK	GK	pH	OM	P	K	PR	O
-0,226	1,000													
0,242	-0,339	1,000												
0,905**	-0,091	0,066	1,000											
0,531	-0,222	-0,023	0,672*	1,000										
0,356	0,170	-0,231	0,719**	0,600*	1,000									
0,739**	-0,579*	0,241	0,562	0,308	0,036	1,000								
-0,418	-0,206	0,229	-0,601*	0,010	-0,652*	-0,260	1,000							
0,428	-0,274	0,578*	0,489	0,468	0,381	0,314	0,011	1,000						
-0,132	0,334	-0,845**	-0,055	0,117	0,080	-0,182	-0,129	-0,724**	1,000					
-0,203	0,270	-0,786**	-0,082	-0,319	0,137	-0,252	-0,432	-0,580*	0,562	1,000				
-0,197	-0,464	0,226	-0,230	0,207	-0,191	0,025	0,508	0,312	-0,330	-0,178	1,000			
0,048	-0,309	-0,265	-0,040	-0,143	-0,183	0,101	-0,062	-0,153	0,164	0,573	0,429	1,000		
-0,148	0,267	-0,197	-0,102	-0,667*	0,029	-0,017	-0,605*	-0,142	-0,052	0,545	-0,238	0,349	1,000	
-0,130	0,658*	0,034	-0,019	-0,402	0,185	-0,245	-0,451	0,103	-0,155	0,189	-0,126	-0,005	0,728**	1,000
0,408	0,335	-0,020	0,411	0,185	0,234	-0,078	-0,257	-0,250	0,198	0,051	-0,548	-0,352	-0,320	-0,165

*,**: Significant at 0.05 and 0.01 probability level, respectively

Table II
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on oil content

	DE	INDIRECT EFFECTS												
NS		**NW**	**ST**	**KW**	**KS**	**PK**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**A**
	0,75	-0,05	-0,36	-0,25	-0,20	0,05	0,48	-0,37	0,83	-0,44	0,13	0,05	0,21	0,43	-0,59
PR		**NW**	**NS**	**ST**	**KW**	**KS**	**PK**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**A**
	1,62	-0,04	0,20	-0,21	-0,28	-0,61	0,01	0,01	-1,09	0,43	0,07	0,26	0,02	-0,24	0,56

Table III
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on nut weight

	DE	INDIRECT EFFECTS													
KW		**NS**	**ST**	**KS**	**PK**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	4,93	0,02	-0,02	1,73	-2,71	-1,29	0,46	-1,43	0,14	-0,07	0,06	0,05	-0,03	0,00	-0,94
IC		**NS**	**ST**	**KW**	**KS**	**PK**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	-2,29	0,14	-0,09	2,77	0,79	-0,14	0,20	-0,92	0,47	-0,21	-0,01	-0,14	-0,01	-0,02	0,18

The path coefficient analysis of direct and indirect effects of important traits on oil content, nut weight, shell thickness, kernel weight, percent kernel and good kernel were presented in Table II, III, IV, V, VI and VII, respectively.

The indirect effect of good kernel on oil content was more than the direct effect, and the direct of protein content on oil content was more than the indirect effects (Table II).

The direct effect of kernel weight on nut weight was more than the indirect effects, and the indirect of kernel weight due to internal cavity on nut weight was more than the indirect effects (Table III).

The direct effect of good kernel on shell thickness was more than the indirect effects; the indirect of good kernel due to pH on shell thickness, and the indirect effects of good kernel and pH due to organic

Table IV
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on shell thickness

	DE	INDIRECT EFFECTS													
GK		**NW**	**NS**	**KW**	**KS**	**PK**	**IC**	**SK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	14,43	-0,71	0,62	-6,81	-1,76	1,23	1,87	-0,03	-7,00	1,34	0,40	-0,46	-0,01	0,17	-2,69
pH		**NW**	**NS**	**KW**	**KS**	**PK**	**IC**	**SK**	**GK**	**OM**	**P**	**K**	**PR**	**O**	**A**
	9,67	0,22	-0,75	0,77	-0,44	0,26	-1,08	0,32	-10,45	-1,30	-0,43	0,50	-0,01	-0,25	2,13
OM		**NW**	**NS**	**KW**	**KS**	**PK**	**IC**	**SK**	**GK**	**pH**	**P**	**K**	**PR**	**O**	**A**
	-2,32	0,34	-0,61	1,14	1,20	0,44	-1,50	1,06	-8,37	5,43	-0,23	1,73	0,05	0,31	0,55

Table V
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on kernel weight

	DE	INDIRECT EFFECTS													
NW		**NS**	**ST**	**KS**	**PK**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	0,34	0,03	-0,05	-0,21	0,06	0,10	0,17	0,35	-0,07	0,03	-0,04	0,00	0,03	-0,01	0,18
KS		**NW**	**NS**	**ST**	**PK**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	-0,39	0,18	0,03	0,01	0,09	0,04	0,00	0,38	0,06	0,05	0,04	-0,01	0,15	-0,03	0,08
PK		**NW**	**NS**	**ST**	**KS**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	0,16	0,12	-0,02	0,05	-0,24	0,01	0,26	0,31	0,04	-0,02	-0,04	-0,01	-0,01	0,01	0,10
SK		**NW**	**NS**	**ST**	**KS**	**PK**	**IC**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	-0,40	-0,14	0,03	-0,05	0,00	-0,10	-0,04	0,01	-0,06	0,07	0,10	0,00	0,13	-0,03	-0,11

Table VI
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on percent kernel

	DE	INDIRECT EFFECTS													
KW		**NW**	**NS**	**ST**	**KS**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	2,21	-3,29	0,02	0,05	0,65	0,61	-0,58	0,53	-0,06	0,00	0,07	-0,02	-0,17	0,00	0,68
KS		**NW**	**NS**	**ST**	**KW**	**IC**	**SK**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	0,92	-1,93	0,06	-0,02	1,49	0,33	0,01	0,50	0,12	0,01	-0,07	-0,06	-1,09	-0,04	0,31
SK		**NW**	**NS**	**ST**	**KW**	**KS**	**IC**	**GK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	0,97	1,52	0,05	0,16	-1,33	0,01	-0,28	0,01	-0,13	0,02	-0,16	-0,03	-0,99	-0,04	-0,43

matter on shell thickness were more than the direct effect (Table IV).

The indirect effect of good kernel due to nut weight, the direct effect of kernel size, the indirect effect of good kernel due to percent kernel and the direct effect of shriveled kernel on the kernel weight were more than others (Table V).

The indirect effects of nut weight due to kernel weight, kernel size and shriveled kernel on percent kernel were more than theirs direct effects (Table VI).

The indirect effects of pH due to shell thickness and organic matter, and the direct effect of pH on good kernel were more than others (Table VII).

Cultivar properties, as well as agroecological conditions, influenced the chemical content of kernel and nut traits in hazelnut (Miletic et al., 1997). In our study, significant differences among elevations were observed for shell thickness; ash content and pH value (Table VIII). The other traits were not significant to elevations. In a study, it was carried out to determine the effects of geographical region and climate on hazelnut production and varietal performance; the climate and soil characteristics and mean yields (g/tree) were differed according to elevations and distances from coast (Baldwin et al., 2001). In the other study, it was determined that

Table VII
The path coefficient analysis of direct effects (DE) and indirect effects of important traits on good kernel

	DE	INDIRECT EFFECTS													
ST		**NW**	**NS**	**KW**	**KS**	**PK**	**IC**	**SK**	**pH**	**OM**	**P**	**K**	**PR**	**O**	**A**
	0,27	-0,06	-0,07	0,07	-0,01	-0,02	-0,02	0,12	0,50	-0,12	-0,07	0,00	-0,03	0,00	0,01
pH		**NW**	**NS**	**ST**	**KW**	**KS**	**PK**	**IC**	**SK**	**OM**	**P**	**K**	**PR**	**O**	**A**
	-0,59	0,03	0,07	-0,23	-0,05	0,03	0,01	0,01	-0,07	0,09	0,08	0,00	-0,01	0,01	-0,11
OM		**NW**	**NS**	**ST**	**KW**	**KS**	**PK**	**IC**	**SK**	**pH**	**P**	**K**	**PR**	**O**	**A**
	0,15	0,05	0,06	-0,22	-0,08	-0,09	0,01	0,02	-0,23	-0,33	0,04	0,01	0,07	-0,02	-0,03

Table VIII
Average values for 16 traits at four elevations in 'Tombul' hazelnut

Traits	Elevation (m)			
	0-50	**100-150**	**200-250**	**300-350**
NW (g)	1,797	1,877	1,757	1,743
NS (cm)	1,670	1,643	1,643	1,663
ST[1] (mm)	0,870 B	1,040 A	0,950 AB	0,980 AB
KW (g)	1,000	1,027	0,953	0,980
KS (cm)	1,277	1,260	1,290	1,263
PK (%)	55,617	54,700	54,220	56,200
IC (mm)	0,990	1,467	1,080	0,937
SK (%)	6,667	7,000	16,333	6,333
GK (%)	66,000	92,667	84,333	92,000
pH[2]	6,343 A	4,817 B	5,737 AB	5,050 B
OM (%)	2,735	2,120	2,087	2,233
P (ppm)	23,737	50,280	92,267	69,710
K (ppm)	425,000	559,667	569,000	354,333
PR (%)	17,230	17,467	16,960	17,617
O (%)	59,950	60,057	59,697	60,533
A[3] (%)	2,697 A	2,467 AB	2,170 B	2,247 B

[1]LSD (0.05) : 0,113
[2]LSD (0.01) : 1,400
[3]LSD (0.05) : 0,301

'Negret' cultivar presented high variations of its characteristics between years and zones of production, and in some areas 'Negret' trees produced nuts with very good chemical characteristics, while in orchards with bad management or with bad environmental conditions nuts produced are of poor quality (Romero et al., 1997). Results of our study are similar to other studies results for some nut, kernel and soil characteristics.

The highest values for these traits were observed at 100-150 m, 0-50 m and 0-50 m, and the lowest at 0-5- m, 200-250 m and 100-150 m, respectively. In other studies that were conducted on 'Tombul' hazelnut, positive significant correlation between shell cracking resistance and shell thickness were determined (Çetiner, 1976; Bostan, 1999), and it was determined that the shell cracking resistance was significantly affected by the elevations (Bostan, 1999). According to these studies, shell thickness was significantly affected by the elevations. Thus, our results for shell thickness were nearly identical to those in previous studies.

The minimum, maximum and mean values and coefficients of variation were presented in Table IX.

The highest coefficients of variation were 71.00 %, 64.10 %, 51.84 %, 32.88 % and 21.56 % for phosphorus, shriveled kernel, potassium, internal cavity and organic matter, respectively.

In previous studies that were carried out in Ordu and Giresun provinces, the coefficient of variation for nut weight, kernel weight and kernel percentage were 10.05 %, 8.10 % and 5.73 % in 'Tombul' (Bostan et al., 1997), for nut weight, shell thickness, kernel weight, internal cavity and percent kernel were 8.62 %, 13.07

Table IX
Minimum, maximum and mean values, and coefficients of variation for 16 traits

	Min.	Max.	Mean	CV
NW (g)	1,69	1,89	1,79	4,30
NS (cm)	1,62	1,69	1,66	1,17
ST (mm)	0,83	1,14	0,96	8,53
KW (g)	0,90	1,07	0,99	5,75
KS (cm)	1,20	1,35	1,27	3,42
PK (%)	53,23	57,63	55,18	2,61
IC (mm)	0,33	1,67	1,12	32,88
SK (%)	2,00	21,00	9,08	64,10
GK (%)	42,00	97,00	83,75	18,56
pH	4,55	6,88	5,49	13,11
OM (%)	1,36	3,35	2,29	21,56
P (ppm)	8,18	150,03	58,99	71,00
K (ppm)	163,00	938,00	477,00	51,85
PR (%)	16,58	18,01	17,32	2,60
O (%)	59,09	61,00	60,06	0,74
A (%)	2,10	2,88	2,40	10,61

%, 12.70 %, 35.43 % and 2.71 % in 'Tombul' (Bostan, 2001), respectively. In our study, nut weight, shell thickness and kernel weight values are lower than literature results, and percent kernel and internal cavity values are similar to those from other studies.

4. CONCLUSION

There are significant correlation and interrelationships among the important soil, nut and kernel traits in 'Tombul' hazelnut cultivar. The shell thickness, ash content in kernel and pH value in soil is significant difference among elevations in Persembe province. It appears that for characteristics internal cavity, shriveled kernel, organic matter, phosphorus and potassium values, coefficients variation are high.

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